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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Preferential Flow Systems Amended with Biogeochemical Components: Imaging of a Two-Dimensional Study" *by* Ashley R. Pales et al.

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OVERVIEW COMMENTS

The manuscript presents experimental results of unstable flow patterns in sand boxes using a light transmission technique that allows identifying differences in flow patterns caused by the composition of the solution of the irrigation water. Plant exudates and soil solutions with different contact angles and surface tensions were tested and related to the effects on the flow finger development. Results demonstrate quite different patterns during the infiltration process. The test comparing various solution compositions is new and the experiments are highly sophisticated and carefully carried out, espe-

cially the combination with the light transmission method that allows determining local water contents is innovative. But the manuscript could be better structured, shortened, and more focused on the analysis of these experiments.

Response: The authors thank Referee #2 for reviewing our manuscript and for the comments about our research: "Results demonstrate quite different patterns during the infiltration process. The test comparing various solution compositions is new and the experiments are highly sophisticated and carefully carried out, especially the combination with the light transmission method that allows determining local water contents is innovative." We will follow the reviewer's suggestions for our manuscript to "be better structured, shortened, and more focused on the analysis of these experiments." We respond below to each of the reviewer's comments and provide detailed information about the proposed revisions.

GENERAL COMMENTS

Claiming this manuscript to be on original research, my immediate impression was that authors should come to the main points more quickly; many references are not further used for the idea and results of this study. When continuing reading, the review part appears more and more excessive; in particular, the multiple referencing is changing the appearance towards a review article in which authors are trying to collect all relevant papers. Such an overview of the literature is quite nice and could be the basis for a separate manuscript. And despite the large number, referencing is still limited, for example, P5 L4: ". . .fronts has been studied primarily in two-dimensional tanks. . .", recently also 3D patterns observed using geo-electrical imaging (e.g., Ganz et al., VZJ 2014, doi:10.2136/vzj2013.04.0074).

Response: The authors thank the reviewer for the comments. We will reduce the introduction and background section of the manuscript as suggested. We will also take into consideration the reference suggested by the reviewer in order to add information about three-dimensional systems (e.g., Ganz et al., VZJ 2014, doi:10.2136/vzj2013.04.0074).

Furthermore, the specific research hypotheses are not so explicitly stated in the introduction (more indirectly somehow within the review), so that the idea of the experiments and reasons for doing it as it was done remained unclear to me at the end of the introduction, where also the objectives were too general. Clear objectives statements are then found in the discussion and again in the conclusions.

Response: The authors thank the reviewer for the comments. We will revise the section related to the specific research hypotheses and objectives to make them more explicit.

The methods are explained very detailed, for Tables and Figures, however, I found it very difficult to understand without having the abbreviations explained in headers and captions (e.g., Suwanee River Natural Organic Matter (SRNOM) acronym etc).

Response: The authors thank the reviewer for the comments. We will describe the abbreviations in headers and captions of the tables and figures in greater detail, as suggested by the reviewer.

One methodological problem that was probably discussed in earlier papers on the technique (?) was unclear to me. This is how to obtain repeatable uniformly compacted sand samples so that the packing effects are not influencing the effects of the solution composition.

Response: The authors thank the reviewer for the comments. To achieve repeatable uniformly compacted sand in the 2D tank, we used a packing device. We will describe the packing device in more detail in the revised manuscript. A Y-shaped sand loader was used to pour the sand in the tank. The Y-shaped sand loader, containing a piece of cloth, was taped above the tank. A sand volume corresponding to the volume of two tanks was loaded into the sand loader. The cloth was then removed from the tank to create a uniform packing of sand within the tank. The sand remaining in the loader and the loader were then removed. To ensure a consistent density of sand in the tank, a plastic rod was used to tap the top edge of the tank to “settle” the top sand layer.

The stated accuracy of bulk density value (1.5043) with 4 digits is quite ambitious. Wetting and especially the partial wetting during the infiltration may change the arrangement of sand particles such that the pore structure may not be always constant. Although results of all three replicate infiltration experiments are provided, the question whether each of the finger pattern is characteristic for each solution and comparable for the replicate is not clear to me. I like the detailed explanation of results but data analysis seems still a bit limited.

Response: The authors thank the reviewer for the comments. We will correct the accuracy of bulk density value. Following the suggestion of Referee #2 regarding the need for more data analysis and assessment and comparison of the “finger pattern” for the different solutions, as well as the comments of reviewer Dr. Maria Dragila, we will revise the discussion section of our manuscript by including a quantitative analysis of the finger pattern/geometry/dimension, i.e. finger width. We will use the scaling theory of Miller and Miller (1956), applied to finger width (Selker and Schroth, 1998). The results of this quantitative analysis will be presented in a table describing the hydrodynamic scaling of finger width measurements resulting from the infiltration of solutions (i.e., control; citrate 0.1 mg/L, 500mg/L; oxalate 0.1 mg/L, 500 mg/L; tannic acid 0.1 mg/L, 500 mg/L, and organics 0.1 and 10 mg/L) in ASTM graded sand C778. Finger width will be scaled to density, gas-liquid interface tension, density and gas-liquid interface tension of pore water, and square root of the cosine of the contact angle. We will scale the finger width using the square root of the cosine of the contact angle, as Culligan et al. (2005) showed that soil sorptivity is a function of the square root of the cosine of the contact angle. This scaling approach will allow us to analyze the finger geometry and determine the parameters of our systems (i.e., solution and interfacial properties) that most influence the flow phenomena in porous media. As also suggested by Dr. Dragila, we will use the Young-Laplace equation which can be used to express capillary pressure at the pore scale as a function of surface tension and contact angle (Lord et al., 1997). We will make a graph of finger properties with capillary pressure as suggested by Dr. Dragila.

Culligan, P. J., Ivanov, V., Germaine, J. T.: Sorptivity and liquid infiltration into dry soil, Adv. Water Resour. 28, 1010–1020. doi:10.1016/j.advwatres.2005.04.003, 2005.
Miller, E. E., Miller, R. D.: Physical theory for capillary flow phenomena, J. Appl. Phys. doi:10.1063/1.1722370, 1956.

Selker, J. S., Schroth, M. H.: Evaluation of hydrodynamic scaling in porous media using finger dimensions, Water Resour. Res. 34, 1935–1940. doi:10.1029/98wr00625, 1998.

Lord, D. L., Demond, A. H., Salehzadeh, A., Hayes, K. I. M. F.: Influence of Organic Acid Solution Chemistry on Subsurface Transport. 2. Capillary Pressure – Saturation, Environ. Sci. Technol. 31, 2052–2058, 1997.

The hypotheses and how the results could be applied to soils remained unclear.

Response: The authors thank the reviewer for the comments. We will add a discussion about the application of our research to soils.

DETAILED COMMENTS

1. The abstract reads well, I only wondered if the conclusions here correspond to those in the conclusion chapter.

Response: The authors thank the reviewer for the comments. We will check the conclusions of the abstract with the conclusions section of the manuscript to ensure their correspondence and will modify them as necessary.

2. Page 7, Lines 15-25: not necessary and unclear

Response: The authors thank the reviewer for the comments. We will remove these lines.

3. Discussion: Starts with the objectives, first paragraph contains hypothesis and should appear as part of the introduction. I was wondering how was equation 2 used?

Response: The authors thank the reviewer for the comments. We will move the first

paragraph of the discussion to the introduction section to make our objectives more explicit, as previously suggested by the reviewer. Equation (2) is used to present the modeling equation to predict finger width and introduce the topic of fingered flow. As mentioned above in the overview comments, a quantitative analysis of the observed fingered flow results will be presented in a table describing the hydrodynamic scaling of finger width measurements resulting from the infiltration of solutions.

4. Page 17, Lines 22-30: This is more or less an introduction to the closer topic and the results seem to confirm existing knowledge.

Response: The authors thank the reviewer for the comments. We will move the text of lines 22-30 to the introduction section.

5. Page 19, Lines about 5-11: This is doubling introduction

Response: The authors thank the reviewer for the comments. We will revise those lines to avoid doubling the introduction, and some of the information in them will be moved to the introduction.

6. Conclusions chapter gives more a summary of results than conclusions.

Response: The authors thank the reviewer for his comments. We will revise the conclusions section to be a conclusion rather than a summary of the results.

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